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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : A61C 13/15		A1	(11) International Publication Number: WO 00/67660 (43) International Publication Date: 16 November 2000 (16.11.00)
(21) International Application Number: PCT/NZ00/00065 (22) International Filing Date: 5 May 2000 (05.05.00)		(81) Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).	
(30) Priority Data: 335663 6 May 1999 (06.05.99) NZ		Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
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(54) Title: CURING DEVICE AND METHOD			
(57) Abstract			
<p>A curing device has special application for curing materials used in dentistry which are curable by blue light with a wavelength of 430nm to 500nm. The device has an elongated housing (1), preferably containing a battery (20) as the electrical power source, and a light emitter (2) in the housing comprises one or more blue light emitting, electrically powered, diodes. The power to the diodes is preferably pulsed so the light emitted is of high intensity. Emitted light may pass through a lens (8) on its way to a director (4) such as a mirror (5) or fibre-optic bundle which redirects the light to emerge from the housing at an angle to its length.</p>			

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Title

Curing device and method

Technical field

This invention relates to an improved curing device and method for primary application in dentistry.

The invention has particular application to the curing of adhesive and filling materials used in dentistry; e.g. light-activated composite fillings or restorations, glass-ionomers, temporary restorative materials, cavity lining materials, luting materials, fissure sealants and bonding materials used in adhesive and general dentistry.

Background art

It is known to use light radiation to cure, i.e. harden or set, adhesive and filling materials. Blue light sources using an incandescent lamp, such as a tungsten-carbide lamp, are known for use in dentistry to cure adhesive and filling materials. These sources radiate energy over a very broad spectral range. Only a small portion of the energy radiated is within the blue part of the spectrum that is useful for activating the curing process. Consequently their use is very inefficient. A high wattage lamp must be used to achieve the intensity of blue light required for curing dentistry materials within a reasonable period.

These high wattage lamps generate a large amount of heat so that cooling fans are required to prevent over-heating of the lamps.

Because only blue light is required for the curing process, filters are used to remove light of other wavelengths.

The high wattage lamps require large power supplies. Mains-powered lamps use transformers which are often heavy, bulky and expensive. The size of the power supply required by these high wattage lamps precludes easy portability.

Cordless battery powered curing lamps are available but the compromise between an adequate operating time and light weight makes these devices inconvenient.

The object of the present invention is to mitigate at least some of these disadvantages, or at least to provide the public with a useful choice.

Disclosure of invention

In a first aspect the present invention broadly consists in a curing device including a housing supporting a light emitter and a light ray director, characterised in that said light emitter comprises one or more light emitting diodes each capable of emitting a blue light when powered by an electric current, and said director is arranged to intercept and redirect rays of said emitted blue light as redirected light rays which travel beyond the confines of said housing.

Preferably one or more of said light emitting diodes are solid state diodes or one or more may be laser diodes.

The curing device may include a lens to concentrate light emitted by said light emitter onto said director which itself may comprise a lens or a prism or a reflector or a fibre optic light guide.

Preferably said curing device includes a pulse circuit by which an electrical current fed to said light emitter is repeatedly turned on and off to pulse said emitted blue light.

In a second aspect the present invention broadly consists in a method of curing an adhesive, filling or lining material used in dentistry, said method comprising the step of exposing said material to blue light emitted by one or more electrically powered light emitting diodes.

Preferably said emitted blue light is pulsed.

Drawings description

The above gives a broad description of the present invention, preferred forms of which will now be described with reference to the accompanying drawings in which:

Figure 1 shows a cross-sectional schematic view of a curing device according to a first embodiment of the current invention; and

Figure 2 shows a cross-sectional schematic view of a curing device according to a second embodiment of the current invention.

Description of best modes

In the method of the current invention as applied to dentistry, materials used in dentistry are cured by exposure to blue light. Examples of these materials include light-activated composite filling or restoration materials, glass ionomers, temporary restorative materials, cavity lining materials, luting cements, fissure sealants and bonding materials used in adhesive or general dentistry. These materials are cured, i.e. transformed from a plastic state to a solid, or more rigid, state by exposure to light having a wavelength in the blue part of the spectrum. According to the current invention such materials are cured by exposure to blue light emitted by one or more light emitting diodes. The light emitting diodes are preferably solid state or laser diodes.

Figures 1 and 2 show curing devices according to the current invention in which a housing 1 contains a light emitter 2. The light emitter includes one or more light emitting diodes (not shown) which emit blue light when powered by an electric current. The blue light has a wavelength known to be suitable for curing materials susceptible to light-activated curing. With the materials routinely used in dentistry the blue light emitting diodes may be semiconductor, solid state or laser diodes emitting a wavelength of blue light of length about 470 nm and within the range of 430 to 500 nm.

The light emitter emits light rays 3 toward a director 4 which intercepts and redirects the light rays. The director may include a reflector 5 as shown in Figure 1, or a light guide 6 as shown in Figure 2, or a prism or lens (not shown).

The exposure time needed to activate the curing process may be reduced by increasing the intensity of the emitted light. This may be done by incorporating a cluster of light emitting diodes in the light emitter. For example, the cluster may contain twenty or fifty diodes. The diodes of the cluster are mounted on a panel or disc 7 which may be about 20 to 30 mm in diameter. A lens 8 placed between the emitter and the director may be used to concentrate emitted light rays 9 on to the director 4.

The intensity of the light emitted from the light emitting diodes may be increased by pulsing the electric current fed to the light emitting diodes. The intensity of the light emitted by the light emitting diodes is dependent upon the level of current passing through the diodes so that when the light emitting diodes are powered with a high but intermittent current the average current may be maintained at or below a safe operating level. In this way the diodes emit a high intensity light without the average current exceeding a safe operating level. For example, light emitting

diodes having a maximum steady operating current of 20 mA, as specified by the manufacturer, may be operated at 100 mA if the current is pulsed, e.g. with a 10% duty cycle. Without pulsing, the 100 mA operating current would burn out the light emitting diodes. An electronic switching circuit may be used to pulse the current fed to the light emitting diodes.

The pulsing of the emitted light may also help to reduce shrinkage of the composite materials being cured. Composite materials can shrink towards the source of light during the curing process. This shrinkage, although only of microscopic proportions, tends to pull the curing material away from the surface to which the material has been applied and to which the material is intended to be bonded by the curing process. Thus shrinkage or retraction of the curing material can impair the bond between the material being cured and the underlying surface.

In a preferred form of the curing device, the housing is dimensioned and shaped so that the curing device may be hand-held in use. To this end, the housing is elongate.

The light rays are directed to radiate from the device transversely, at an angle to the longitudinal axis or length of the device, so that the radiated light may be easily directed onto a target area within the patient's mouth.

The curing device may also have a tapered tip 11 as seen in Figure 1 or a narrowed tip 12, having a smaller diameter than the main part of the housing, as seen in Figure 2. The tapered or narrowed tip facilitates the insertion of the end of the curing device, from which blue light is radiated, into the patient's mouth so that the light may be readily aimed at a target area, e.g. a biting surface or a rear surface of a tooth.

The light may be radiated at an angle of less than 90° to the longitudinal axis of the curing device, as shown in the figures. Otherwise the light may be radiated at 90°, or at more than 90° so that the light is angled back from the tip toward the other end of the housing so that light may be easily directed onto hard-to-reach target areas, e.g. the rear surface of teeth.

In Figure 1 the director includes a mirror 5 which reflects and redirects light rays 13 so that they radiate at an angle to the elongate axis of the housing and out through an orifice 14 or window, (not shown). The orifice or window is in a side wall 15 adjacent the distal end of the tapered tip 11. The window, where provided, is substantially transparent to the blue wavelengths activating the curing process.

The mirror 5 shown in Figure 1 is planar. Alternatively, the mirror may be concave or convex. Light rays redirected by the mirror may converge at a zone. The distance from the mirror to the zone of convergence of the radiated rays 13 can be predetermined by the shape of the mirror 5, amongst other things such as the properties of the lens 8.

In Figure 2 the director includes a light guide 16. The light guide has a bend 17 so that the rays of light 18 emitted from the curing device emerge at an angle to its the longitudinal axis. The light guide may be a fibre optic light guide and in one preferred embodiment the light guide 16 is a bundle of discrete optic fibres.

In another embodiment, not shown, the light guide is a bundle of discrete optic fibres, each fibre originating at a respective light emitting diode. The fibres are directly coupled to the diodes so that light may be transferred without any intervening concentrator or lens.

In another embodiment, not shown, the director is provided by a lens integrally moulded with the light emitter. A light emitting diode is encapsulated in a material that is transparent to blue light and is shaped and arranged to provide the light emitting diode with a light-directing lens. This integral emitter-director is mounted at the tip of the curing device at an angle to direct light back toward the other end of the curing device to facilitate, for example, the directing of the emitted blue light on to tooth surfaces. The light emitter may be mounted on a swivel or flexible arm to facilitate the directing of blue light over a range of angles to the axis of the curing device.

The light emitter of the curing device may be powered by a battery 20 which may be rechargeable. The curing device may include a control switch 21 which connects the battery to the light emitter. The control switch may be operated by a button 22. The control switch may include a timer to power the light emitter for a pre-selected time period known to activate the curing process of the material to be cured. The control switch may include circuitry to power the light emitter with pulses of current having a magnitude greater than a safe maximum average operating current specified for the emitter.

In one embodiment the timer controls the sounding of an audible signal at the end of a first period of light emission, upon which the operator may release the button 22 to turn off the light emitter. If the operator maintains the light emission (by not releasing the button 22), the timer controls the sounding of a second audible signal at the end of a second additional period of light emission. The timer may be arranged to switch the light emitter off at this time, even if the operator fails to release the button.

Preferably, the light emitting diodes used in the method and device of the current invention generally emit only light close in wavelength to the wavelength of light

known to effect cure of the materials being cured, eg only blue light, so the efficiency is high. The light emitting diodes produce little heat thereby avoiding the need for cooling fans as used to cool the incandescent lamps of the prior art curing devices. This simplifies construction and allows a reduction in size and operating noise levels. A light weight cordless portable curing device can be battery powered while still providing a satisfactory operating time because of the low power required by the light emitting diodes of the current invention.

The lifetime of light emitting diodes is far greater than that of the incandescent lamps of the curing devices of the prior art. This results in large savings and an almost maintenance-free curing device.

The invention uses low cost components in a small, compact and conveniently hand-held and preferably cordless curing device.

Claims

1. A curing device for curing materials, said device including a housing (1) supporting a light emitter (2) and a light ray director (4), characterised in that said light emitter comprises one or more light emitting diodes each capable of emitting a blue light when powered by an electric current, and said director is arranged to intercept and redirect rays of said emitted blue light as redirected light rays which travel beyond the confines of said housing.
2. A curing device as claimed in claim 1 wherein said one or more light emitting diodes are solid state diodes.
3. A curing device as claimed in claim 1 wherein said one or more light emitting diodes are laser diodes.
4. A curing device as claimed in any preceding claim wherein said curing device includes a lens (8) to concentrate light emitted by said light emitter (2) onto said director (4).
5. A curing device as claimed in any preceding claim wherein said director (4) comprises a lens or a prism or a reflector (5) or a fibre optic light guide (16).
6. A curing device as claimed in any preceding claim wherein said curing device includes a pulse circuit by which an electrical current fed to said emitter is repeatedly turned on and off to pulse said emitted blue light.
7. A curing device as claimed in any preceding claim wherein said emitters are fed an electric current sourced from an electrical storage cell or battery (20) contained in said housing (1).

8. A curing device as claimed in any preceding claim wherein said housing (1) is elongate and said redirected light rays leave said housing substantially adjacent one end thereof and travel external to said housing in a direction which diverges from the longitudinal axis of said housing.
9. A method of curing an adhesive, filling or lining material used in dentistry, said method comprising the step of exposing said material to blue light emitted by one or more electrically powered light emitting diodes.
10. A method as claimed in claim 9 wherein said emitted blue light is pulsed.

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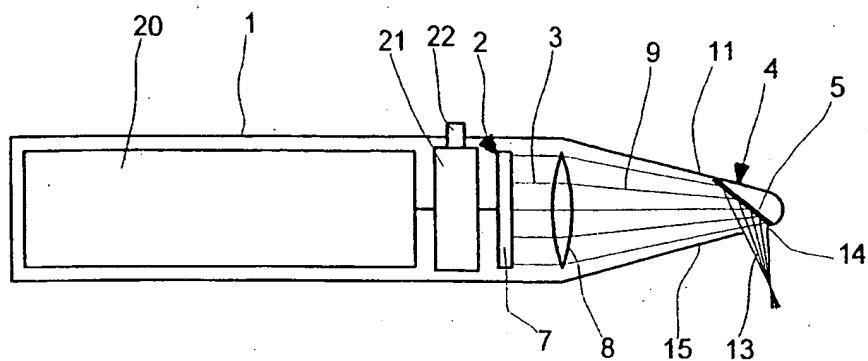


Figure 1

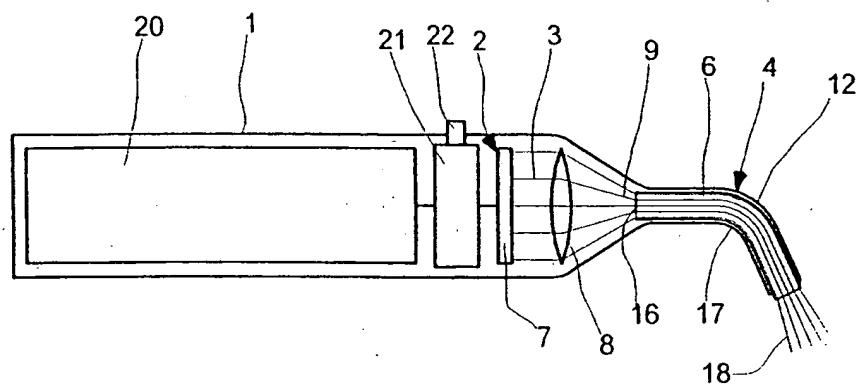


Figure 2

INTERNATIONAL SEARCH REPORT

Int'l Application No

PCT/NZ 00/00065

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61C13/15

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 634 711 A (KAYSER ROY ET AL) 3 June 1997 (1997-06-03) column 1, line 64 -column 2, line 47 column 3, line 6 -column 4, line 31 column 5, line 21 - line 29 figures 1,3 ---	1-3,5-10
X	WO 97 36552 A (MACKELLAR GEOFFREY ROSS ;DOUBE CHRISTOPHER PHILIP (AU); NULITE SYS) 9 October 1997 (1997-10-09) page 2, line 9 - line 39 page 3, line 29 -page 5, line 1 page 6, line 27 - line 37 page 7, line 35 -page 8, line 24 figures 1,2 ---	1,4-6, 8-10
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Date of the actual completion of the international search

28 August 2000

Date of mailing of the international search report

04/09/2000

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 10, 31 October 1996 (1996-10-31) & JP 08 141001 A (OSADA RES INST LTD), 4 June 1996 (1996-06-04) abstract -----	1,4,5, 7-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/NZ 00/00065

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